THE IMPORTANCE OF FOOD QUALITY IN SORGHUM IMPROVEMENT PROGRAMS

H. Doggett*

Grain quality is of prime importance to plant breeders in the third world, because sorghum improvement programs in the Semi-Arid Tropics (SAT) are concerned with the grain as a human food. The acceptability of the stover as fodder for cattle is a consideration to be remembered, but it is incidental to the main breeding program. Nevertheless, juicy stem and sweet juice are worth picking up if they appear in the segregating breeding material. Breeders have always concentrated on improving yield, and in more recent years, stability of yield. However, in the past, too little stress was laid on grain quality.

Cryptic Quality

The argument for working on nutritional value is based on the fact that the farmer is producing the grain for food. If plant breeders can improve the nutritional quality of that food, then this should be done, subject to yield and yield stability being maintained. For the same effort, the farmer gets the same quantity of better food.

We are fortunate in having the comprehensive review by Hulse, Laing, and Pearson (1980) to help us in assessing grain quality needs. Their summaries of analyses show that there is considerable variation in sorghum for levels of protein, lysine, lipids, carbohydrates, fibre, calcium, phosphorus, iron, thiamine, and niacin, and also in the isoleucine/leucine ratio. Provided that suitable analytical techniques are available, any

* Associate Director, Agricultural Food and Nutrition Sciences, IDRC Regional Office, Private Bag, Peradeniya, Sri Lanka

of these nutrients could be the subjects of successful plant breeding programs. Are any of them worthwhile? These authors point out that the lysine content of sorghum is among the lowest of any of the cereal grains, and they note the great importance of sorghum in the diets of the people of the semi-arid tropics.

They recommend that research be continued to stabilize a higher-than-average lysine content in combination with an average (say 10 percent) protein content. There can be no question but that their recommendation is correct: the protein is being produced in any case: if more of it could be utilized for food without the need to supplement with quantities of other foods containing abundant lysine, so much the better.

The initial optimism that this would prove possible has not yet been justified. The Ethiopian high lysine types at present are only of use as immature grains; the P721 mutant seems more hopeful, but the farmer won't accept lower yields unless he receives a higher price. At the present time, it is not possible to recommend any good sources of high lysine which do not have undesirable pleiotropic effects, other than P721 perhaps, for use in ordinary breeding programs. The effects of recurrent selection on this character have not yet been tried seriously, to my knowledge. Brhane Gebrekidan, in Ethiopia is using the dented grains of the local high-lysine types as indicators of crosses in a recurrent selection program, since plump seeds on such heads are hybrid seed, not selfs. It will be interesting to see in due course whether any plump seeded high lysine types occur.

Of the other cryptic quality factors, the leucine: isoleucine ratio appears to be important, but there are no quick screening techniques such

as the UDY system which would make a breeding program possible at present. Even where quick screening techniques are available, the breeding programme requires a lot more work than when dealing with evident characters, and the breeder needs to be quite certain that success will be really worthwhile.

Any product must be economically advantageous to the farmer. He must either like it a lot for his own use, or else get a premium price for his product.

It will be realised that nuritional factors--the cryptic characters,--have to take their place in the list of priorities among all the yield and yield characters needed, as well as the evident quality factors. It is not possible to breed for everything at once.

Evident Quality Characters

Two evident quality characters are the presence of tannins in the grains, and grain mould damage to the grains.

The tannin situation is governed very largely, but not entirely, by the grain-eating bird population. This is particularly true in Africa with the Quelea birds, which descend on the small grain crops like locusts. The tannins in sorghum are polyphenols, which render the grain astringent and unpalatable, especially in the green stage. In some varieties, the astringency diminishes on ripening, until it almost disappears. Such sorghums can be ground into flour and used for food in the normal way, although the product is coloured, often quite strongly.

This provides the only character which plant breeders can use to select for better grain quality among the bitter sorghums of the bird areas. To be useful, the bird population needs to be small enough at the

grain ripening stage for damage levels to be acceptably low. High tannin levels result in low digestibility, and reduced Protein Efficiency Ratio levels.

Such high tannin sorghums therefore present problems of utilization which have been largely solved by the people dependent upon them. Germinating the sorghum grain in wood-ash is said to reduce the tannin content, and this process is the basis of much of the beer-making found in Africa. In some regions, there are special brewing sorghums grown which have high polyphenol contents, and no doubt flavour is a consideration in this situation, although the malting germination is still done in moist wood-ash. For areas where the sorghum grains are predominantly brown, the beer is often the method of using the grain for food. Westerners think of the tannins as improving the flavour of the beer, whereas in Africa the manufacture of the beer is one method of reducing the tannins and improving the digestibility of the proteins. Some people obtain much of their nourishment from these beers, which contain a lot of solids.

Grain moulds are another source of grain deterioration which the plant breeder can do a great deal to reduce. The ICRISAT grain mould resistance program has succeeded beyond my original expectations, and mould resistance should be a component of any food quality program where grains are liable to ripen in some seasons under conditions which favour grain mould development.

Food Quality

Attention has already been drawn to areas which have special problems of bird incidence and/or grain moulds which have an over-riding influence on

the type of sorghum grown. The people have had to learn to use those sorghums for food, and their standards of good or bad are relative within those grain types.

When these constraints are absent, the conventional wisdom of the plant breeder in Africa was to associate good food quality with clean, white, cream, or even yellow corneous grains, often shiny with a thin pericarp. This character is less important where the pericarp is removed by "pearling" with a pestle and mortar, as is frequently done in Africa. Colour is also important, as minor damage can result in a pinkish colour in the prepared food. Plants lacking this pigment (tan plants) were therefore chosen. The very corneous grains were harder to grind, and one was never certain whether this character was desired primarily for food quality, or primarily for grain storage. Plant breeders looked first at the plant, then at the grain. They bit the grain to judge hardness, presence of a testa, and the amount of corneous endosperm, and appearance. That simple procedure determined which plants had "quality" grains.

Another achievements of the past five years has been the classification of sorghum food types on a worldwide basis, and correlations of food types with grain characteristics. Keeping quality and food quality have to go together in some areas, so that the cooking methods have been developed to suit the grain types which store well. Looking at the data available at ICRISAT on the corneous endosperm scores, those with a very corneous endosperm are used for the thick-paste products, i.e., the Tô and Ugali. These foods belong to areas where grain storage is a problem. At the other extreme, Injera belongs to the cool highlands, where such problems are not so severe. Tortillas are a food of the highlands of Central and

South America originally, the main maize growing zones - cooler also, and needing only a low percentage of corneous endosperm. At present, Roti comes lower in the corneous score scale, but this would well be revised upwards later. Kisra seems to be a compromise: perhaps literally a compromise. The ancient people on the eastern side of Africa grew their sorghum in the highlands where no doubt they developed the fermented bread. Moving into the lowlands, they needed better keeping quality, and so a more corneous endosperm. Perhaps we do not yet have a sufficient understanding of the grain which makes good Kisra. In the tables I have seen of a comparison of 25 cultivars, the highest score for Kisra for any cultivar is 2.1. A lower score indicates a higher quality. All the other forms achieve at least one rating of 1.0, except for Tortilla, which received 1.2 for CSH-5 (The Ugali comparison is incomplete, only 11 of the 25 cultivars were tested).

The milling information also favours the harder grains: the Injera types cannot be expected to mill well, while the Dobbs types underline what had already been realized - that the prospects of milling off a bird resistant testa are not good. We need harder grains with the testa, but even if these had been obtained, the milling losses would probably still have been unacceptably high, because so much has to be removed from the outer layers of the grain.

Pearling and Milling

Work has been in progress over the past few years to study the pearling and grinding of sorghum grain. IDRC supported a project at Maiduguri in Nigeria to try out small scale pearling and grinding machinery; this was followed by work in Botswana, and an active program has continued. It would seem from the viewpoint of the plant breeder that we must learn how to

handle the existing popular grain types, but in due course the best types for mechanical handling will be identified, and can be bred into the breeding programs.

Plant Breeding

Turning to the plant breeding considerations, yield and quality will always be the primary objectives of our programs. Before a new cultivar is released to farmers, it is important that its food quality should have been properly evaluated by people through tasting and cooking tests. It may be necessary to sacrifice a little yield in favour of better quality; we all know the situation in which the improved cultivar is grown for sale and the traditional type retained for food. There is a trade off: this can only be balanced up by those involved in the production and consumption of grain.

Our programs must be matched to the local needs. It is no good aiming for a white corneous grain type in bird areas, unless one has first identified a part of the season into which a short-duration type might fit, when the birds have moved elsewhere to nest. If we are in brown-grained sorghum areas, how is the grain used for food? Do the local types become less astringent as they ripen? If so, we must see that this character is in our good lines. Is the grain germinated in the course of preparing beer or food? If so, under what conditions? In damp wood-ash? Our lines must be as good as the local cultivars when subjected to these same treatments.

In many other areas, the old system of looking at plant colour, grain colour, pericarp, absence of a testa, and proportion of corneous endosperm while selecting in the field will sort out a great deal of the material. Later, more refined small scale tests can be done, and we can

expect ICRISAT to come up with the most useful of these tests for the particular food type popular in each area. This is of course the key to breeding for quality.

The old "rough and ready" was used for lack of any objective tests. The development of small-scale tests for food types and quality will provide the tools for the breeder to develop PROPER quality programmes. We shall be hearing more of these in this symposium. This is the key. Find the Plant Breeder the tools, and he will do the job. A testing panel of local sorghum eaters should be assembled to test the products before they go to the multiplication stage.

I suspect that, with both Injera and Kisra, small-scale tests will be needed which involve actually making the final product, compared with a standard local type.

Lastly, how do our potential new lines keep in store? There are two main methods of storage: threshed grain, and unthreshed heads. The pests of the former are the rice weevil-Tribolium complex. There are various ways of estimating losses from these. I always used net bags containing 100 grains each, buried in a tin of weevilly grain, each tin being a replication. The damaged grains were counted every fortnight. Ten replications were used and also two local cultivars as controls. The whole head system of storage can be simulated by hanging heads on wires in a room where there is some Angoumis grain moth (Sitotroga) infested grain spread out on the floor. Again, use plenty of replication, compare with two checks, and count at intervals.

1. Make sure that your new lines will yield equally well as, or better than, the farmers' cultivars under the conditions he actually uses, but

are much more responsive to good management than his types.

2. Ensure that your new lines are of acceptable quality for preparing the local food, or drink.

3. Ensure that your new lines will keep in storage reasonably well when compared with local cultivars.

Reference

Hulse, J.H., Laing, E.M., and Pearson, O.E. 1980. Sorghum and the millets. Their composition and nutritive value. IDRC Ottawa, Canada: Academic Press. 997 pp.

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